§12. Long Pulse Operation of ICRF Antenna in Vacuum Test

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The distinguished features of the ion cyclotron range of frequency (ICRF) heating in LHD are capable of the steady-state heating. All components have been developed for the steady-state operation. The pulse length more than two minutes has been achieved by the ICRF heating only. Further long pulse operation was planned in the former cycle of experiment but it was canceled by arcing of the antenna.

The first problem was observed in two years ago. Arcing occurred at the insulating ceramic bearing of the antenna moving structure. Circle in Fig.1 shows the part that arcing occurred. The metal plate at the tip of the antenna back-plate connected the antenna to the wall. Then, we tried to fix the arcing problem by eliminating the current loop removing the metal plate. However, the arcing occurred again and we tried to fix by more actively ground the antenna on the wall.

Figure 2 is the picture of the 3.5U antenna inside of LHD vacuum vessel and looking-up the coaxial section between the Faraday shield and the feed-through. As pointed out by the circles, the thin copper plates are installed to connect the antenna and the wall electrically. The width and thickness of the plate are 5cm and 0.2 mm and the material is deoxidized-copper. Total four points per antenna are grounded.

Long-pulse operation of ICRF antenna was carried out in vacuum to test the effect of the grounding plates. The antenna voltage of $20kV_{0p}$ was applied to the 3.5U and 3.5L antenna for 20 minutes separately and five minutes at the same time. This antenna voltage corresponds to the 500 – 600kW in the two antenna loops in the normal low-density plasmas. Figure 3 shows the time trace of the antenna voltage, the forward power and the reflected power in the case of sole operation of the 3.5U antenna. The spikes in the trace are caused by the RF discharge. Around 500 seconds, the RF discharge occurred frequently and very thin plasma was generated. We tried to see the light of the arcing at the antenna moving structure through the viewing window but could not observe any lights. The test was stopped at the 20 minutes because of the temperature increase at the feed-through, which was not cooled so extensively. After the long-pulse test, there was no damage at the grounding plates.

In conclusion, the grounding plates work well and the arcing at the antenna moving structure is suppressed. This type of arcing does not occur in the long-pulse vacuum test. Temperature increase at the feed-through will be suppressed by using the water-cooling method, which has been tested in the R & D experiments already.

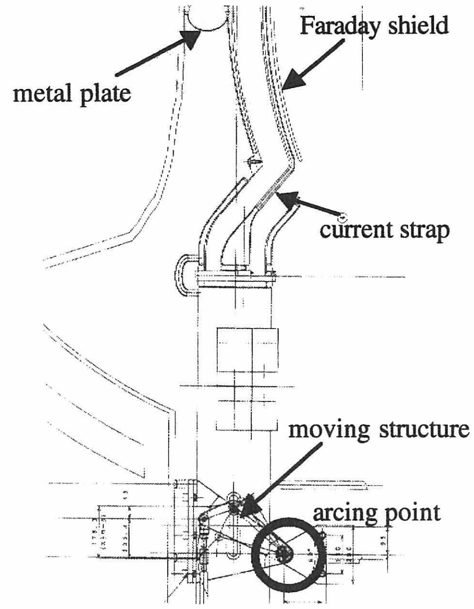

Fig.1. Drawing of the cross section of the 3.5L antenna. Circle shows the point that arcing occurred.

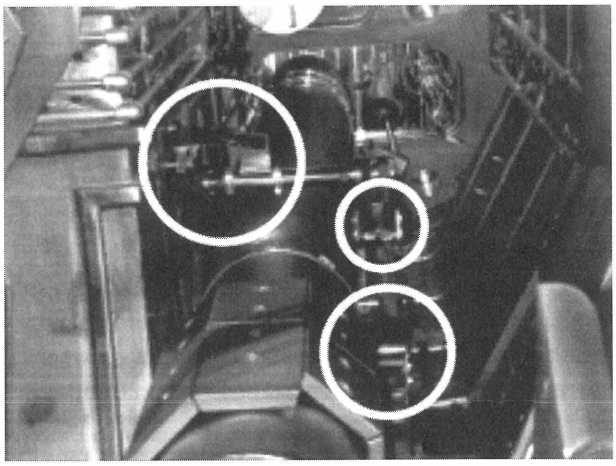

Fig.2. Picture of the 3.5U antenna looking-up the coaxial section between the Faraday shield and the feed-through. Grounding plates are installed as shown in circles.

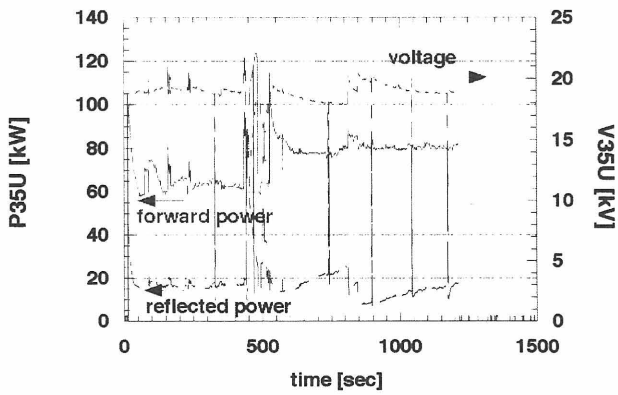

Fig.3. Time trace of the antenna voltage, forward power and reflected power during long-pulse vacuum test for 3.5U antenna.